Two-order parameter model for phase transitions in the presence of an intermediate metastable state with applications

F. Paladi, A. Barsuk

Department of Theoretical Physics, Moldova State University, Republic of Moldova

The previously proposed model for the kinetics of first-order phase transitions [1] was generalized for r-order and m-control parameters. The generalized parametric model is based on the Landau-type kinetic potential. Bifurcation and stability analysis for the first order phase transition was performed in the presence of an intermediate metastable state. We have also analysed the impact of an external field on phase transition. The control parameters presented in the kinetic potential are associated to the diffusion and viscosity as intrinsic characteristcs of the material, as well as to the system heterogeneity and the influence of constant or periodic external field. Anomalous generation and extinction phenomenon of crystal nuclei at very low temperatures in non-equilibrium supercooled liquids containing hydroxyl group, namely o-benzylphenol, salol, and 2,2'-dihydroxybenzophenone, observed during the progress of crystal nucleation and growth below the glass transition temperature reflect the impact of real structural fluctuation on the irreversible structural relaxation in supercooled liquids and glasses [2, 3].The values of control parameters are estimated accordingly to the experimental data for the mean transition time between stable liquid and crystalline phases in the region of coexistence of two liquid states for lysozyme protein [4]. The study of the influence of constant or periodic external field on transition dynamics in the presence of two fluctuating order parameters was achieved by the construction of phase portraits for different values of the field coupling parameter. The impact of constant external field on the system in the presence of an intermediate metastable state would reduce the stability of system and, therefore, decrease the transition rates from the stable liquid state to the solid state in the presence of metastable liquid state, thats why the presence of the constant external field would increase the mean transition time, similar to the model involving a single order parameter [1]. On the other hand, the presence of an external periodic forcing would lead to the acceleration of phase transition in the presence of an external periodic field [5]. In general, the obtained results are related to the theory of structural relaxation in complex systems, and some aspects of kinetics of phase transitions in the presence of an intermediate metastable state, including generation of crystal nuclei as clusters of the new phase.

[l] A. Barsuk et al., Physica A **392**, 1931 (2013).

[2] F. Paladi, M. Oguni, Phys. Rev. B **65**, 144202 (2002).

[3] F. Paladi, M. Oguni, J.Phys. Cond. Matter **15**, 3909 (2003).

[4] W.R. Rypniewski et al., Biochemistry **32**, 9851 (1993).

[5] G. Nicolis, C. Nicolis, Physica A **323**, 139 (2003).